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Subduction initiation is accompanied by rapid fore-arc extension and detachment-mode spreading in the upper plate

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Most ophiolites have geochemical signatures that indicate formation by suprasubduction seafloor spreading above newly initiated subduction zones, and hence they record fore-arc processes operating following subduction initiation. They are frequently underlain by a metamorphic sole formed at the top of the downgoing plate and accreted below the overlying suprasubduction zone lithosphere immediately following ophiolite formation. Paleomagnetic analyses of ophiolites can provide important insights into the enigmatic geodynamic processes operating in this setting via identification of tectonic rotations related to upper plate extension. Here we present net tectonic rotation results from the Late Cretaceous Mersin ophiolite of southern Turkey that document rapid and progressive rotation of ophiolitic rocks and their associated metamorphic sole. Specifically, we demonstrate that lower crustal cumulate rocks and early dykes intruded into the underlying mantle section have undergone extreme rotation around ridge-parallel, shallowly-plunging axes, consistent with oceanic detachment faulting during spreading. Importantly, later dykes cutting the metamorphic sole experienced rotation around the same axis but with a lower magnitude. We show that these rotations occurred via a common mechanism in a pre-obduction, fore-arc setting, and are best explained by combining (hyper)extension resulting from detachment-mode, amagmatic suprasubduction zone spreading in a fore-arc environment with a recently proposed mechanism for exhumation of metamorphic soles driven by upper plate extension. Available age constraints demonstrate that extreme rotation of these units was accommodated rapidly by these processes over a time period of $< \sim 3$ Myr, comparable with rates of rotation seen in oceanic core complexes in the modern oceans.